VEGETATION CLASSIFICATION AND SURVEY

International Association for Vegetation Science (IAVS)

Vegetation Classification and Survey 5: 75–84
doi: 10.3897/VCS.119968

LONG DATABASE REPORT ECOINFORMATICS

Nordic-Baltic Grassland Vegetation Database (NBGVD) – current state and future prospects

Nadiia Skobel[1,2*], Łukasz Kozub[1*], Iwona Dembicz[1], Steffen Boch[3], Hans Henrik Bruun[4], Olha Chusova[5], Valentin Golub[6], Aveliina Helm[7], Dmytro Iakushenko[8,9], Paweł Pawlikowski[1], Piotr Zaniewski[10], Jürgen Dengler[11,12]

1 *Department of Ecology and Environmental Conservation, Institute of Environmental Biology, Faculty of Biology, University of Warsaw, Warsaw, Poland*
2 *Department of Botany, Kherson State University, Kherson, Ukraine*
3 *Biodiversity and Conservation Biology, WSL Swiss Federal Research Institute for Forest, Snow and Landscape, Birmensdorf, Switzerland*
4 *Department of Biology, University of Copenhagen, Copenhagen, Denmark*
5 *Department of Geobotany and Ecology, M.G. Kholodny Institute of Botany of the National Academy of Sciences of Ukraine, Kyiv, Ukraine*
6 *Togliatti, Russia*
7 *Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia*
8 *Department of Botany and Ecology, University of Zielona Góra, Zielona Góra, Poland*
9 *Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine*
10 *Department of Forest Botany, Institute of Forest Sciences, Warsaw University of Life Sciences, Warsaw, Poland*
11 *Vegetation Ecology Research Group, Institute of Natural Resource Sciences (IUNR), Zurich University of Applied Sciences (ZHAW), Wädenswil, Switzerland*
12 *Plant Ecology, Bayreuth Center of Ecology and Environmental Research (BayCEER), University of Bayreuth, Bayreuth, Germany*

Corresponding author: Jürgen Dengler (juergen.dengler@zhaw.ch)

Academic editor: Florian Jansen ♦ **Linguistic editor:** Hallie Seiler
Received 31 January 2024 ♦ **Accepted** 1 April 2024 ♦ **Published** 23 May 2024

Abstract

This Long Database Report describes the historical background and current contents of the Nordic-Baltic Grassland Vegetation Database (NBGVD) (GIVD-code EU-00-002). NBGVD is the EDGG-associated collaborative vegetation-plot database that collects vegetation-plot data of grasslands and other open habitats (except segetal and deep aquatic vegetation) from the Nordic-Baltic region excluding Germany, namely Belarus, Denmark, Estonia, Faroe Islands, Finland, Iceland, Latvia, Lithuania, Norway, N Poland, NW Russia, Svalbard and Jan Mayen, and Sweden. Target vegetation types are lowland grasslands and heathlands, arctic-alpine communities, coastal communities, non-forested mires and other wetlands, rocky, tall-herb and ruderal communities. As of March 2024, it included 12,694 relevés recorded between 1910 and 2023. These were mainly digitised from literature sources (84%), while the remainder comes from individual unpublished sources (16%). The data quality is high, with bryophytes and lichens being treated in more than 80% of all plots and measured environmental variables such as topography and soil characteristics often available in standardised form. A peculiarity of the Nordic-Baltic region are the relatively small plot sizes compared to other regions (median: 4 m^2). The available data stem from 35 vegetation classes, with *Koelerio-Corynephoretea*, *Festuco-Brometea*, *Sedo-Scleranthetea*, *Molinio-Arrhenatheretea* and *Scheuchzerio-Caricetea* being most frequent. We conclude that NBGVD provides valuable data, allowing interesting analyses at the regional scale and fills gaps in continental to global analyses. Still, since there are many more data around, we ask interested readers to contribute their own data or help find and digitise old data from the literature.

Taxonomic reference: TURBOVEG species list "Europe".

Syntaxonomic reference: Mucina et al. (2016).

Abbreviations: EDGG = Eurasian Dry Grassland Group, EVA = European Vegetation Archive, GIVD = Global Index of Vegetation-Plot Databases, NBGVD = Nordic-Baltic Grassland Vegetation Database

* Nadiia Skobel and Łukasz Kozub shall be considered joint first authors.

Keywords

Arctic-alpine vegetation, Baltic region, coastal vegetation, ecoinformatics, European Vegetation Archive (EVA), grassland, macroecology, mire, Nordic region, plot size, relevé, vegetation-plot database

GIVD Fact Sheet: Nordic-Baltic Grassland Vegetation Database (NBGVD)

GIVD Database ID: EU-00-002			**Last update:** 2024-03-29
Nordic-Baltic Grassland Vegetation Database (NBGVD)			**Web address:** https://edgg.org/databases/Regional-databases
Database manager(s): Jürgen Dengler (dr.juergen.dengler@gmail.com); Łukasz Kozub (lkozub@uw.edu.pl)			
Owner: Consortium of the Nordic-Baltic Grassland Vegetation Database (NBGVD Consortium)			
Scope: The former name of this database was "Database Dry Grasslands in the Nordic and Baltic Region" (with a narrower scope). Now all available relevés of grasslands and other open habitats from the study region (Iceland, Svalbard and Jan Mayen, Faroe Islands, Norway, Sweden, Finland, Denmark, N Poland, Lithuania, Latvia, Estonia, Belarus, NW Russia) are collected.			
Abstract: The Nordic-Baltic Grassland Vegetation Database (NBGVD) (GIVD-code EU-00-002) is the EDGG-associated collaborative vegetation-plot database that collects vegetation-plot data of grasslands and other open habitats (except segetal and deep aquatic) from the Nordic-Baltic region, except Germany, namely Belarus, Denmark, Estonia, Faroe Islands, Finland, Iceland, Latvia, Lithuania, Norway, N Poland, NW Russia, Svalbard and Jan Mayen, Sweden. Target vegetation types are lowland grasslands and heathlands, arctic-alpine communities, coastal communities, non-forested mires and other wetlands, rocky, tall-herb and ruderal communities. As of January 2024, it included 12,694 relevés, collected between 1910 and 2023, which were mainly digitised from literature sources (79%), while the remainder comes from individual unpublished sources (21%). The data quality is high, with bryophytes and lichens being treated in 95% of all plots and measured environmental variables such as topography and soil characteristics often available in standardised form. A peculiarity of the Nordic-Baltic region are the relatively small plot sizes compared to other regions (median: 4 m2). The available data stem from 35 vegetation classes, with Koelerio-Corynephoretea, Festuco-Brometea, Sedo-Scleranthetea, Molinio-Arrhenatheretea and Scheuchzerio-Caricetea being most frequent. We conclude that NBGVD provides valuable data, allowing interesting analyses at the regional scale and filling gaps in continental to global analyses. Still, there are many more data around, and we thus ask interested readers to contribute own data or help with finding and digitising old data from the literature.			
Availability: according to a specific agreement		**Online upload:** no	**Online search:** no
Database format(s): TURBOVEG		**Export format(s):** TURBOVEG, Excel	
Plot type(s): normal plots		**Plot-size range (m²):** 0.04 to 600	
Non-overlapping plots: 12694	**Estimate of existing plots:** 50000	**Completeness:** 25%	**Status:** ongoing capture
Total no. of plot observations: 12694	**Number of sources (biblioreferences, data collectors):** 124		**Valid taxa:** 1750
Countries (%): BY: 12.9; DK: 1.7; EE: 10.3; FI: 1.7; LV: 2.2; LT: 1.0; NO: 10.2; PL: 24.8; RU: 1.2; SE: 24.6			
Formations: Non Forest: 60% = Terrestrial: 60% (Non arctic-alpin: 60% [Semi-natural: 60%])			
Guilds: all vascular plants: 100%; bryophytes (terricolous or aquatic): 86%; lichens (terricolous or aquatic): 83%			
Environmental data (%): altitude: 27.9; slope aspect: 33.9; slope inclination: 29.4; microrelief: 1.9; surface cover other than plants (open soil, litter, bare rock etc.): 21.9; other soil attributes: 10.4; soil pH: 26.2; land use categories: NA; soil depth: 15.3; other attributes: Cation exchange capacity, base saturation, soil organic matter, CaCO3 content			
Performance measure(s): presence/absence only: 0%; cover: 100%; number of individuals: 0%; measurements like diameter or height of trees: 0%; biomass: 0%; other: 0%			
Geographic localisation: GPS coordinates (precision 25 m or less): 26.9%; point coordinates less precise than GPS, up to 1 km: 40.9%; small grid (not coarser than 10 km): 28.5%; political units or only on a coarser scale (above 10 km): 3.7%			
Sampling periods: before 1920: 0.5%; 1920-1929: 6.0%; 1930-1939: 2.0%; 1940-1949: 4.9%; 1950-1959: 2.6%; 1960-1969: 7.1%; 1970-1979: 4.2%; 1980-1989: 8.4%; 1990-1999: 26.3%; 2000-2009: 21.0%; 2010-2019: 13.6%; after 2020: 3.4%; unknown: 0.0%			
Information as of 2024-03-29; further details and future updates available from http://www.givd.info/ID/EU-00-002			

Introduction

Vegetation-plot databases have an enormous potential for vegetation ecology, macroecology and global-change studies (Dengler et al. 2011; Wiser 2016) as they allow for generalization beyond the local or regional extent. This potential is increasingly harvested through big continental to global databases such as the European Vegetation Archive (EVA; Chytrý et al. 2016), the global database "sPlot" (Bruelheide et al. 2019) or the specialised high-quality database of Palaearctic open habitats "GrassPlot" (Dengler et al. 2018). Publications making use of data from EVA, for example, have shed light on the broad-scale classification of dry grassland types (Willner et al. 2019), the frequency and distribution of neophytes in European grasslands (Axmanová et al. 2021) and the relationship of functional vs. phylogenetic diversity in grasslands (Večeřa et al. 2023). The sPlot database, among others, was used to model how alpha-diversity patterns in grasslands and forests globally vary across grain sizes (Sabatini et al. 2022) and to test what drives stability in grasslands (Engel et al. 2023). However, such broad-scale analyses strongly depend on balanced data coverage across regions.

Within Europe, the Nordic countries (Iceland, Svalbard and Jan Mayen, Norway, Sweden, Finland), NW Russia and Belarus are generally much underrepresented (see Chytrý et al. 2016; recent update at https://euroveg.org/img/map-eva-square.png), particularly in the case of grasslands. Denmark and Poland seem to be represented quite well according to the EVA map, but this does not reflect the reality for many international studies: the main source of Danish data, the NATURDATA.DK database (GIVD ID EU-DK-002), is represented in EVA only with presence/absence data, which thus cannot be used for studies requiring cover data, while data from the Polish Vegetation Database (EUR-PL-001) contained in EVA have repeatedly not been released for specific research projects. Thus, in many international studies the models derived for the Nordic-Baltic regions have weaknesses due to sparse data from grasslands (e.g. Axmanová et al. 2021; Večeřa et al. 2021, 2023). Even for fen vegetation, one of the most typical vegetation types of the boreal zone, the current data in EVA give the false impression that these would be rare in middle and northern Sweden and Finland (see maps in Jiménez-Alfaro et al. 2023).

In addition, most of the Nordic-Baltic countries (except Germany and Poland) do not have a strong phytosociological tradition as they were in the realms of the Russian (Aleksandrova 1973) or Nordic (Trass and Malmer 1973; see also Pätsch et al. 2019) schools of vegetation ecology. Unlike the Zurich-Montpellier school (phytosociology), collecting large numbers of vegetation plot records (relevés) for broad-scale classification was never prevalent in these two schools, leading to a much lower number and density of historic relevés than in other parts of Europe (see Schaminée et al. 2009; Chytrý et al. 2016). Unlike many other European countries, most of the countries of the region (except Germany, Poland and Lithuania) still do not have national vegetation-plot databases (https://www.givd.info; see Dengler et al. 2011). This gap is partly filled for forest and mire vegetation by the Nordic Vegetation Database (EU-00-018) and the European Mire Vegetation Database (EU-00-022), but a major gap remains for grasslands and other open habitat types. The Nordic-Baltic Grassland Vegetation Database (NBGVD) aims to fill this gap. It emerged from a database focused on the dry grasslands of the region (Dengler et al. 2006b; Dengler and Rūsiņa 2012), but was later expanded to include all grasslands and other non-forest vegetation types (Dengler and Kozub 2022). Recently, the content of NBGVD has been significantly increased and its quality and consistency improved. With this Long Database Report, we would like to provide a current overview on the organisation of NBGVD, give detailed statistics on its content and outline future avenues of development as well as potential uses of its data.

Scope of NBGVD

The Nordic and Baltic region in the sense of NBGVD is defined as the combined territories of Denmark, Faroe Islands, Iceland, Svalbard and Jan Mayen, Norway, Sweden, Finland, NW Russia, Belarus, Estonia, Latvia, Lithuania and the Pleistocene lowlands of N Poland and N Germany. This region approximately corresponds to the maximum extension of the Northern European ice shield during the Pleistocene (Lang 1994). However, German plots have recently been excluded from NBGVD and transferred to our sister database GrassVeg.DE (Dengler et al. 2017, 2018a). In the future, we anticipate a similar arrangement with the Lithuanian Vegetation Database (EU-LT-001).

According to its Bylaws, NBGVD's main foci are "all natural and semi-natural grasslands s.l.". However, any vegetation types except forests, shrublands, true aquatic communities and arable fields are collected. According to Mucina et al. (2016), this means the following vegetation classes (although sources that contain a small fraction of other classes are digitised completely):

- Lowland grassland and heathland communities: *Calluno-Ulicetea*, *Festuco-Brometea*, *Koelerio-Corynephoretea canescentis*, *Molinio-Arrhenatheretea*, *Nardetea*, *Sedo-Scleranthetea*
- Arctic-alpine communities: *Carici rupestris-Kobresietea bellardii*, *Juncetea trifidi*, *Loiseleurio procumbentis-Vaccinietea*, *Salicetea herbaceae*, *Saxifrago cernuae-Cochlearietea groenlandicae*
- Coastal communities: *Ammophiletea*, *Cakiletea maritimae*, *Crithmo-Staticetea*, *Juncetea maritimi*, *Saginetea maritimae*, *Spartinetea martimae*, *Thero-Salicornietea*
- Wetland (amphibian) communities: *Isoeto-Nano-Juncetea*, *Littorelletea uniflorae*, *Montio-Cardaminetea*, *Oxycocco-Sphagnetea*, *Phragmito-Magno-Caricetea*, *Scheuchzerio palustris-Caricetea fuscae*
- Rocky communities: *Asplenietea trichomanis*, *Thlaspietea rotundifolii*
- Tall-herb communities: *Trifolio-Geranietea sanguinei*, *Mulgedio-Aconitetea*
- Ruderal communities: *Artemisietea vulgaris*, *Bidentetea*, *Epilobietea angustifolii*, *Polygono-Poetea annuae*, *Sisymbrietea*

Further, the relevés must refer to contiguous plots with a specified area in the range of 0.09 to 400 m^2. Relevés with a direct estimate of percent cover (see Dengler and Dembicz 2023) are preferred, but those with any other cover or cover-abundance measure (e.g. variants of the Braun-Blanquet or Hult-Sernander scales) are also accepted, while pure presence-absence data are not.

History and governance of NBGVD

The database originated from data collected by J. Dengler aimed at the phytosociological classification of the dry grasslands of the region, at that time managed in the software for vegetation plot handling SORT (Ackermann and Durka 1998). It was subsequently transferred to TURBOVEG 2.0 (Hennekens and Schaminée 2001) and be-

came a collaborative project under the name "Database Dry Grasslands in the Nordic and Baltic Region" (see Dengler et al. 2006b; Dengler and Rūsiņa 2012). In 2016, the scope was widened to include all grasslands s.l., and thus, the name was changed to "Nordic-Baltic Grassland Vegetation Database" (NBGVD; Dengler and Kozub 2022). NBGVD is registered in the Global Index of Vegetation-Plot Databases (GIVD; Dengler et al. 2011) under the ID EU-00-002 (see GIVD Fact Sheet). It is one of currently five regional grassland vegetation databases associated with the Eurasian Dry Grassland Group (EDGG; https://edgg.org/), namely the Balkan Dry Grassland Database (BDGD; EU-00-013; Vassilev et al. 2012), the German Grassland Vegetation Database (GrassVeg.DE; EU-DE-020; Dengler et al. 2017, 2018), the Romanian Grassland Database (RGD; EU-RO-008; Vassilev et al. 2018) and the Ukrainian Grassland Database (UGD; EU-UA-001; Kuzemko 2012).

NBGVD is a self-governed consortium in which every data contributor becomes a member. It is regulated by a set of Bylaws (Suppl. material 1). The members elect a Custodian and a Deputy Custodian for two-year renewable terms to coordinate the database, with J. Dengler the current Custodian and Ł. Kozub the Deputy. NBGVD contributes its content at regular intervals to EVA and sPlot, allowing its members to opt-in for EVA and sPlot publications as co-authors and propose studies using the continental and global databases themselves. The NBGVD website is https://edgg.org/databases/Regional-databases.

Starting with 7,675 plots in 2012 (Dengler and Rūsiņa 2012) and 9,839 plots in 2022 (Dengler and Kozub 2022), NBGVD has now grown to 12,694 plots as of March 2024. This means a net growth of 5,019 plots over12 years. However, the number of plots that were newly made available to EVA during this period was as high as 9,143, since more than 4,000 plots have since been excluded from NBGVD. Before 2022, all plots from Germany were transferred to GrassVeg.DE (Dengler et al. 2017, 2018). Moreover, we recently excluded plots that are now included in a specialised EVA database from Latvia, the Semi-natural Grassland Vegetation Database of Latvia (EU-LV-001), to avoid duplicates in EVA. Apart from this increase in quantity, we also took great efforts to improve the quality and consistency of the plot data. This included identifying and correcting erroneous entries, filling in important header data fields (e.g. vegetation class), and improving coordinate precision (in the predecessor database under SORT, coordinates were only given with 0.1° precision).

Data management

Currently, the database is managed using the latest version of the TURBOVEG 2.0 software (Hennekens and Schaminée 2001). When we encountered cover-(abundance) scales not predefined in TURBOVEG, we added their definitions, i.e. the symbol, min, max and mean cover values of each cover class to the respective definition table of the program. The taxonomy of the database is based on the built-in "Europe" species list relying on the Flora Europaea (Tutin et al. 1964–1993) with some additions of vascular plant taxa that could not be easily attributed to any of the already existing taxonomic concepts as well as bryophytes and lichens (for these groups, TURBOVEG "Europe" does not have a clearly documented source). The header data in NBGVD consist of five groups: (1) standard TURBOVEG fields, (2) fields required by EVA (see Chytrý et al. 2016), (3) fields required by sPlot (see Bruelheide et al. 2019), (4) fields needed for NBGVD project management, and (5) structural and environmental variables provided with the data. The fields of the categories (1)–(4) are filled completely, while the fields of category (5) are created and filled upon availability and carefully curated for consistency (e.g. identical units).

Content of NBGVD

The 12,694 vegetation plots currently included in NBGVD originate from data published by consortium members (19.5%) and other authors (45.6%), while the rest are unpublished relevés from consortium members (34.9%). In total, the NBGVD currently contains data from 124 different sources (Suppl. material 2) contributed or digitised by 27 contributors, four of which contributed more than 10% each (Suppl. material 3: table S3.1).

NBGVD has data from all 13 countries or territories within its geographic scope, with the numbers being highest in the Polish lowlands (24.8%) and Sweden (24.6%), followed by Belarus (12.9%) and Estonia (10.3%) (Table 1). The plot density strongly differs between territories, with a maximum of 515 plots in 1,000 km² on the Faroe Islands and values below 1 plot in 1,000 km² in Finland and NW Russia (Table 1). The plot density also varies within territories, with maxima on Saaremaa on the Estonia West coast and on the Faroe Islands. NBGVD still contains very few plots from Russiaand the northern parts of Finland and Sweden (i.e. north of 62° latitude).

Table 1. Countries and other territories covered by NBGVD with their area and available plot number in March 2024, expressed in absolute and relative terms and density per surface area.

Country or part of country	Area included [km²]	Number of plots	Fraction [%]	Plot density [plots/1,000 km²]
Belarus	207,595	1,632	12.9	7.9
Denmark (mainland)	43,094	214	1.7	5.0
Estonia	45,339	1,309	10.3	28.9
Faroe Islands	1,398	720	5.7	515.0
Finland	338,145	222	1.7	0.7
Iceland	103,125	460	3.6	4.5
Latvia	64,589	280	2.2	4.3
Lithuania	65,300	127	1.0	1.9
Norway (mainland)	324,220	716	5.6	2.2
Poland (lowlands)	230,107	3,149	24.8	13.7
Russia (NW part)	956,305	158	1.2	0.2
Svalbard and Jan Mayen	62,045	587	4.6	9.5
Sweden	450,295	3,120	24.6	6.9
Total	**2,891,557**	**12,694**	**100.0**	**4.4**

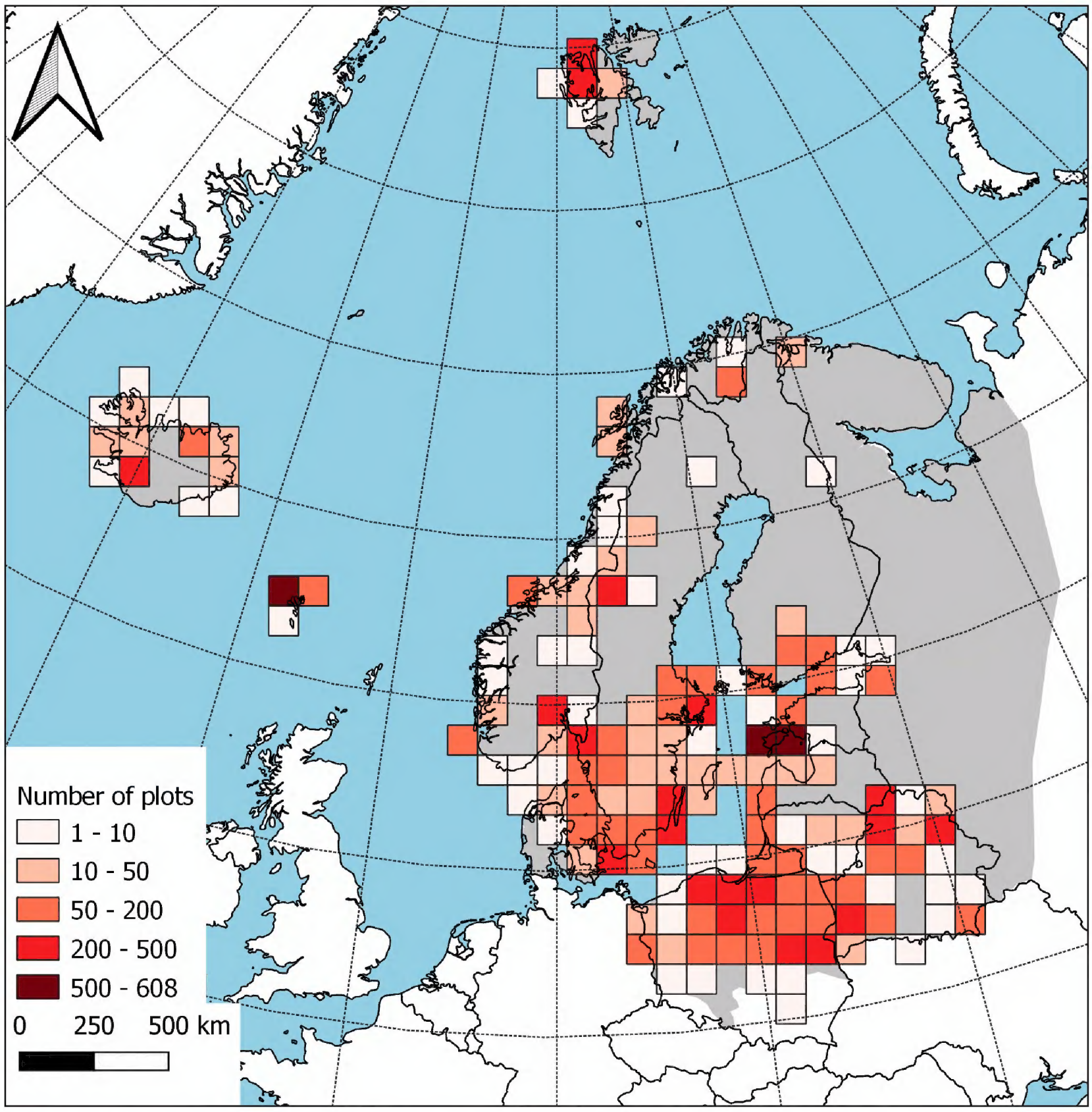

Figure 1. Spatial distribution of the 12,694 vegetation plots contained in NBGVD in March 2024. The grey shading indicates the geographic scope of NBGVD, while the colour intensity of the 100 km × 100 km grid cells represents the number of plots contained in NBGVD.

The data were collected from 1910 to 2023 (median: 1997), with a peak in the two decades from 1990 to 2009, but otherwise with rather uniform distribution (Figure 2). Plot sizes vary widely within the allowed range, with 1 m^2 (30.0%), 4 m^2 (17.1%), 25 m^2 (13.5%), 0.64 m^2 (7.0%), and 0.25 m^2 (4.0%) being most frequent (Figure 3, Suppl. material 3: table S3.2). Only 79 (0.6%) plots lack plot size information; these are mostly individual relevés from older literature sources (Suppl. material 3: table S3.2). The overall median of plot sizes in the database is 4 m^2, while in six territories (Belarus, Denmark, Estonia, Faroe Islands, Latvia, Norway) plot sizes of 1 m^2 and smaller prevail (Suppl. material 3: table S3.2). Plot sizes larger than 4 m^2 dominate only in Iceland (median: 6 m^2), NW Russia (median: 7.5 m^2), Poland (25 m^2), and Latvia (100 m^2) (Suppl. material 3: table S3.2). Since a large fraction of plots was digitised from older literature often including only coarse information on sampling sites, the coordinate precision in NBGVD varies widely, from GPS precision (5 m and less: 26%)

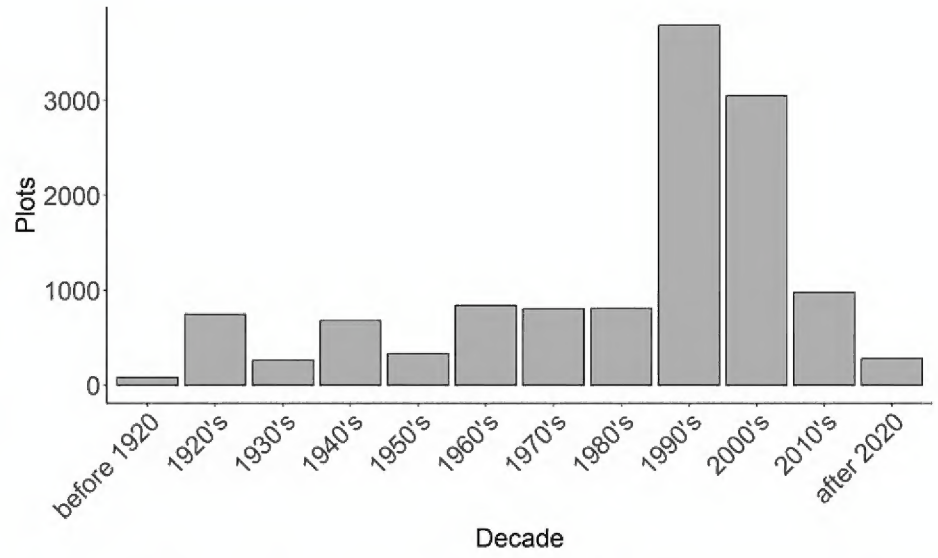

Figure 2. Temporal distribution of the 12,694 vegetation plots contained in the NBGVD in March 2024.

to 1 km (42%) and more than 1 km (32%) (Figure 4). Currently, NBGVD contains datasets recorded with nine different cover or cover-abundance scales, dominated by the 7-step (35.0%) and 9-step variants (28.3%) of the Braun-Blanquet scale, followed by the Hult-Sernander

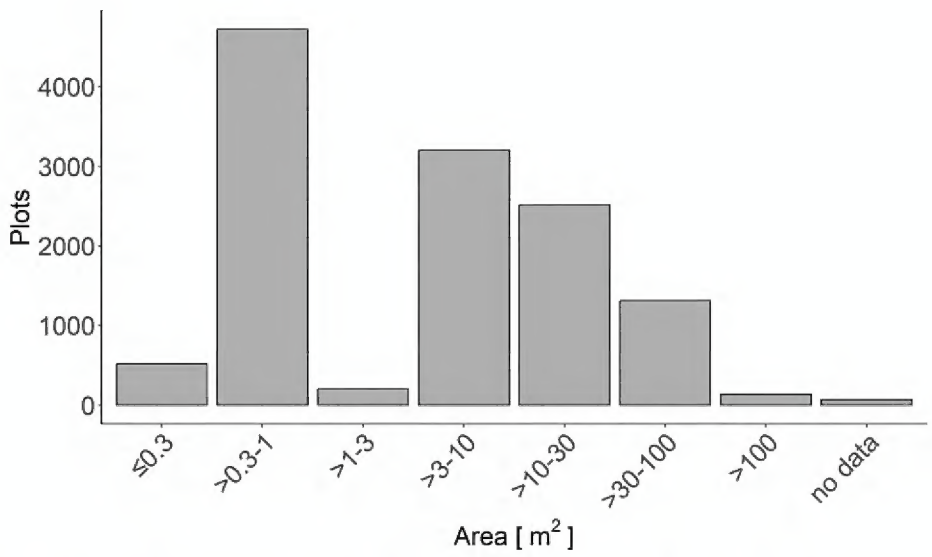

Figure 3. Distribution of the plot sizes of the 12,694 vegetation plots contained in the NBGVD in March 2024.

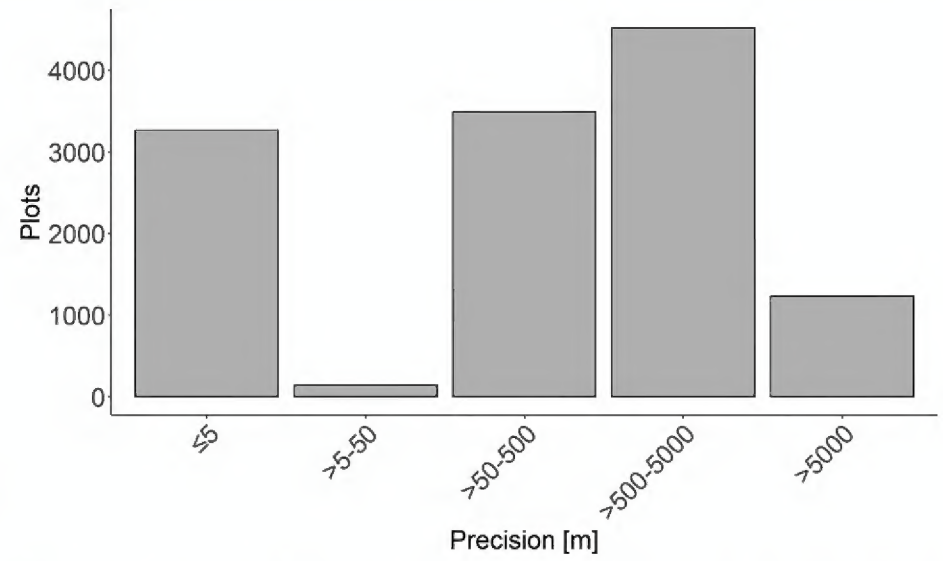

Figure 4. Distribution of coordinate precision of the 12,694 vegetation plots contained in the NBGVD in March 2024.

scale (12.9%), percent cover (2.2%) and the Londo scale (0.5%). Four datasets used idiosyncratic scales defined for specific projects (21.1% altogether).

Where this information is available, NBGVD stores the association/community, alliance, and order assignment of the vegetation plots in the source, without attempting harmonization. Moreover, more than 75% of the plots in NBGVD are currently assigned to a vegetation class according to Mucina et al. (2016), based on the original assignment in the source, expert interpretation of the species composition or the EUNIS habitat classification (Chytrý et al. 2020). For the latter, we ran the EUNIS expert system implemented in JUICE (Tichý 2002) over our relevés, and if the resulting habitat type was completely nested in one class, we assigned the relevé there. A total of 35 vegetation classes are present, with seven representing more than 2% of the plots each: *Koelerio-Corynephoretea canescentis* (1955 plots; 15.4%), *Festuco-Brometea* (1843; 14.5%), *Sedo-Scleranthetea* (1053: 8.3%), *Molinio-Arrhenatheretea* (933; 7.3%), *Scheuchzerio palustris-Caricetea fuscae* (833; 6.6%), *Trifolio-Geranietea sanguinei* (574; 4.5%), *Salicetea herbaceae* (322; 2.5%), and *Juncetea maritimi* (282; 2.2%) (for details, see Suppl. material 3: table S3.3).

NBGVD also contains various header data fields for structural and environmental variables. Apart from several environmental header data fields with free text, such as land use and soil texture class, there are currently 11 measured environmental variables referring to topography and soil characteristics (Table 2). Among these, elevation, aspect, inclination and pH (H_2O) are available for at least one quarter of the plots (Table 2).

It is worth mentioning that according to the header data, bryophytes were treated in nearly 86% of the plots and lichens in 83% of the plots in the database, meaning that NBGVD can provide real absences of non-vascular taxa. The five most frequent vascular plant taxa (after merging taxa determined at different levels across plots into some broader concepts) are *Festuca ovina* aggr. (30.6% of the plots), *Achillea millefolium* aggr. (28.9%), *Galium verum* (25.2%), *Hieracium pilosella* aggr. (23.5%), and *Festuca rubra* aggr. (23.4%) (Suppl. material 3: table S3.4). The five most frequent bryophyte taxa are *Ceratodon purpureus* (13.5% of the plots with determined bryophytes), *Polytrichum piliferum* (9.7%), *Hypnum cupressiforme* aggr. (9.7%), *Racomitrium canescens* aggr. (8.9%), and *Syntrichia ruralis* aggr. (8.50%) (Suppl. material 3: table S3.5). Among lichens, *Cetraria islandica* (10.0% of the plots with determined lichens), *Cladonia arbuscula* aggr. (9.8%), *Cladonia furcata* aggr. (7.3%), *Cetraria aculeata* (6.8%) and *Peltigera rufescens* (4.7%) are the most frequent taxa (Suppl. material 3: table S3.6).

Table 2. Measured environmental variables contained in NBGVD with their degree of availability and the distribution of values.

Variable	Unit	TURBOVEG name	Available (%)	Min	Max	Mean	Median
Elevation	m a.s.l.	ALTITUDE	27.9%	-0.5	1350	253	135
Slope aspect	°	EXPOSITION	33.9%	0	360	158	180
Slope inclination	°	INCLINATIO	29.4%	0	90	13	5
Microtopography	cm	MICROTOP	1.9%	1	30	5	4
Mean soil depth	cm	SOILDEPTH	15.3%	0	60	13	8.5
pH (H_20)	-	PH_H20	26.2%	1.70	8.50	5.21	5.40
pH (KCl)	-	PH_KCL	8.9%	2.70	7.70	5.88	6.60
Cation exchange capacity	meq/100 g	CEC	1.8%	1.2	99	37	36.5
Base saturation	%	BASE_SAT	1.8%	67.15	100	99	100
Soil organic matter	mass %	ORG_MAT	10.4%	0	78.7	14	12.2
$CaCO_3$ content	mass %	LIME_PERC	0.5%	0.4	80	19	12.3

Resume and outlook

With the current NBGVD update, the data coverage of grasslands s.l. in the Nordic and Baltic regions has significantly improved in EVA and sPlot, thus facilitating regional, continental, and global analyses of non-forest vegetation. Aside from coming from an underrepresented region, the data in NBGVD are particularly useful for their good quality regarding the treatment of non-vascular plants (currently in more than 80% of all plots and thus high above the EVA average) and the careful curation of environmental header data. However, plot sizes could be a challenge when analysing data from the Nordic-Baltic region together with data from the rest of Europe, as the median plot sizes used in most of the NBGVD countries (4 m^2 or even 1 m^2) are well below the prevailing practice in most other European countries (Chytrý and Otýpková 2003). The data of NBGVD can be requested from NBGVD directly or via EVA and sPlot, following their respective Bylaws. In fact, they are frequently used in EVA and sPlot projects. However, in early 2024, we received the first direct data request to NBGVD, interestingly for a pan-European study where the proponent combined the European grassland data from sPlotOpen (a stratified, open access subset of an older EVA release: Sabatini et al. 2021) and GrassPlot (Dengler et al. 2018b), but wanted to achieve a data coverage in the Northern countries comparable to the rest of Europe.

Even with the release of this NBGVD update, the data coverage in the region is still poorer than in many other parts of Europe. Thus, we aim at expanding NBGVD further through the inclusion of additional data which could stem from the digitisation of older published sources from the past or from recent data (published and unpublished) in digital format from current and new consortium members. Promising avenues to retrieve further historical sources are searching for the sources underlying the few synthetic vegetation overviews of the region (e.g. Dierßen and Dierßen 1996) and systematic screening of botanical and ecological journals of the region (e.g. Acta Phytogeographica Suecica, Blyttia,…). Anyone who has data to contribute that match our scope is welcome to contact J.D. or Ł.K. However, please note that NBGVD is an all-purpose database with minimal requirements for data to be provided (see above). If you have data that meet the higher standards of our partner database GrassPlot (Dengler et al. 2018; Biurrun et al. 2019), particularly if they have been sampled on precisely delimited plots of one of the GrassPlot standard sizes (e.g. 0.1, 1, 10 or 100 m^2), we recommend contributing these to GrassPlot, not to NBGVD. In this case they would not only be available for EVA and sPlot projects, but also for GrassPlot projects (see https://edgg.org/databases/GrassPlot) (Figure 5). Likewise, data from repeatedly sampled plots (permanent or quasi-permanent plots) would likely be more beneficial if contributed to ReSurveyEurope

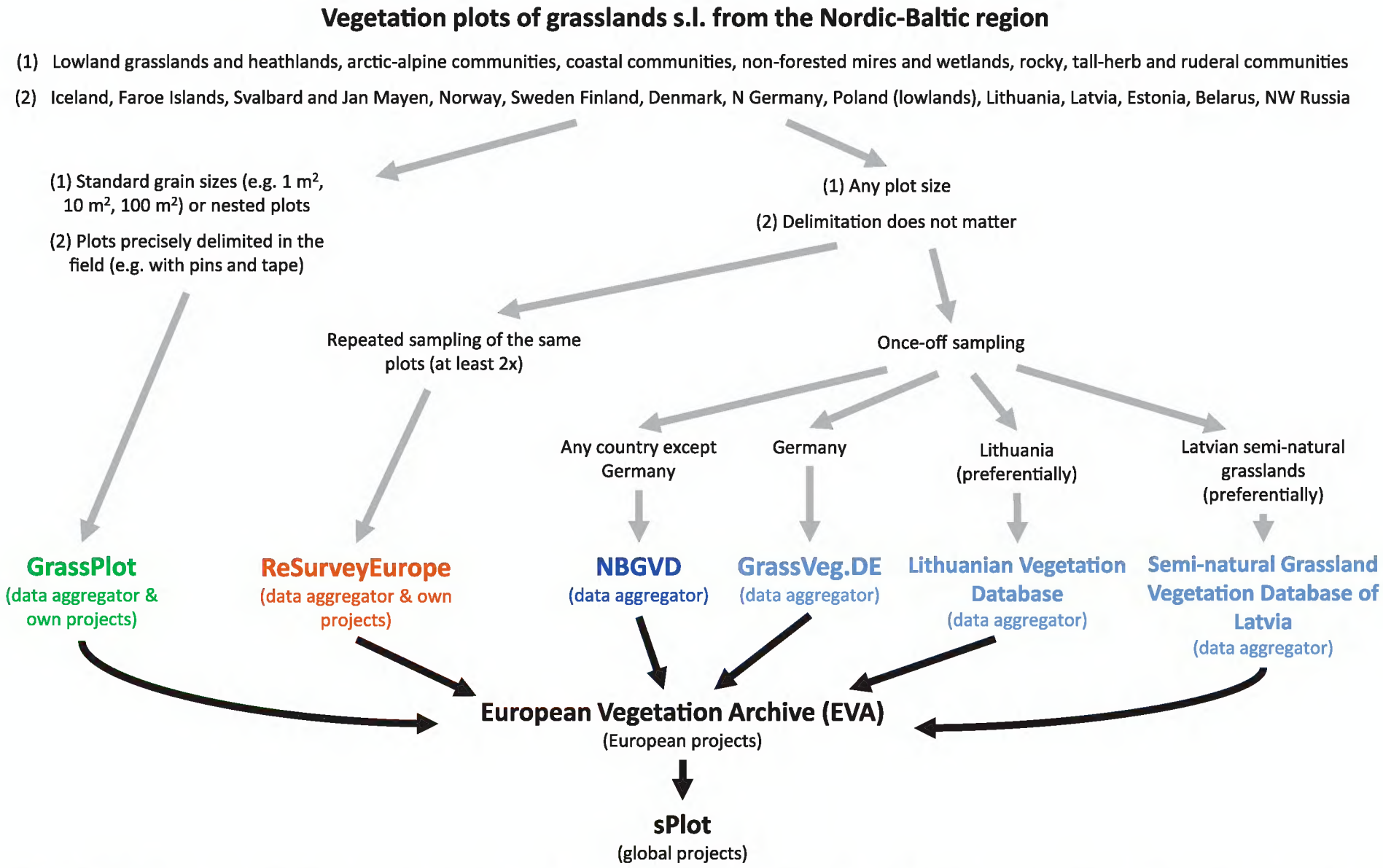

Figure 5. Decision tree (grey) on how to contribute grassland plots s.l. from the Nordic-Baltic region to national and international vegetation-plot databases to achieve optimal benefit for data contributors and for science. The black lines indicate the flow of data to databases of higher aggregation levels.

(Knollová et al. 2024) (Figure 5). Note that despite belonging to the Nordic-Baltic region, grassland plots s.l. from Germany not meeting the GrassPlot criteria should go to GrassVeg.DE, and those from Lithuania and the semi-natural grasslands from Latvia preferentially to the respective national databases (Figure 5).

Since NBGVD has no funding, we rely on voluntary work both for digitising and georeferencing plots and for further improvement of the quality of already included plots (e.g. to increase the georeferencing precision of plots provided in the past). We also would like to adjust the taxonomic backbone to the current European standards of vascular plants, bryophytes and lichens to allow the most effective use of the data. Here, the "Euro+Med augmented" standard from Dengler et al. (2023), based on Euro+Med (2023) for vascular plants and Hodgetts et al. (2020) for bryophytes, appears particularly promising.

We anticipate that having more high-quality plot data from the Nordic-Baltic region will not only improve the validity of future macroecological and global-change studies for this region, but be particularly beneficial for the development of data-based broad-scale vegetation classification systems, of which there are only a few for the open habitats of the region so far, namely for the vegetation of fens (Peterka et al. 2017), coastal dunes (Marcenò et al. 2018), bogs (Jiroušek et al. 2022), and springs (Peterka et al. 2023) across Europe and for the rocky outcrop communities in the Nordic-Baltic region (Dengler and Löbel 2006; Dengler et al. 2006a).

Data availability

The database described here is collective property with semi-restricted access. Data can be requested from the last author following the rules defined in the NBGVD Bylaws (Suppl. material 1).

Author contributions

JD and ŁK coordinate the NBGVD Consortium as Custodian and Deputy Custodian, respectively. NS and ŁK currently manage NBGVD and have added new relevés and improved existing data in recent years. JD, ŁK, NS, and ID planned and wrote the report together, while all other authors contributed data, edited and approved the manuscript.

Acknowledgements

We acknowledge the data contributions by Martin Diekmann, Christian Dolnik, Anna Maria Fosaa (deceased), Thomas Gregor, Antti Hovi (contact lost), Nele Ingerpuu, Barbara Juskiewicz-Swaczyna, Brigitta Laime, Swantje Löbel, Meelis Pärtel, Solvita Rūsiņa, Wojciech Stachnowicz, Annett Thiele, Germund Tyler (deceased), and Sergej Znamenskiy. We thank Stephan Hennekens and Ilona Knollová for their help with data handling and the improvement of data consistency. We thank Florian Jansen and two anonymous reviewers for careful comments on a former version of the manuscript and Hallie Seiler for linguistic editing.

References

Ackermann W, Durka W (1998) SORT 4.0 – Programm zur Bearbeitung von Vegetationsaufnahmen und Artenlisten – Handbuch. Munich, DE, 138 pp.

Aleksandrova VD (1973) Russian approaches to classification of vegetation. In: Whittaker RH (Ed.) Ordination and classification of communities, Junk, The Hague, NL, 493–427. https://doi.org/10.1007/978-94-010-2701-4_17

Axmanová I, Kalusová V, Danihelka J, Dengler J, Pergl J, Pyšek P, Večeřa M, Attorre F, Biurrun I, … Chytrý M (2021) Neophyte invasions in European grasslands. Journal of Vegetation Science 32: e12994. https://doi.org/10.1111/jvs.12994

Biurrun I, Burrascano S, Dembicz I, Guarino R, Kapfer J, Pielech R, Garcia-Mijangos I, Wagner V, Palpurina S, … Dengler J (2019) GrassPlot v. 2.00 – first update on the database of multi-scale plant diversity in Palaearctic grasslands. Palaearctic Grasslands 44: 26–47. https://doi.org/10.21570/EDGG.PG.44.26-47

Bruelheide H, Dengler J, Jiménez-Alfaro B, Purschke O, Hennekens SM, Chytrý M, Pillar VD, Jansen F, Kattge J, … Zverev A (2019) sPlot – a new tool for global vegetation analyses. Journal of Vegetation Science 30: 161–186. https://doi.org/10.1111/jvs.12710

Chytrý M, Otýpková Z (2003) Plot sizes used for phytosociological sampling of European vegetation. Journal of Vegetation Science 14: 563–570. https://doi.org/10.1111/j.1654-1103.2003.tb02183.x

Chytrý M, Hennekens SM, Jiménez-Alfaro B, Knollová I, Dengler J, Jansen F, Landucci F, Schaminée JHJ, Aćić S, … Yamalov S (2016) European Vegetation Archive (EVA): an integrated database of European vegetation plots. Applied Vegetation Science 19: 173–180. https://doi.org/10.1111/avsc.12191

Chytrý M, Tichý L, Hennekens SM, Knollová I, Janssen JAM, Rodwell JS, Peterka T, Marcenò C, Landucci F, … Schaminée JHJ (2020) EUNIS Habitat Classification: expert system, characteristic species combinations and distribution maps of European habitats. Applied Vegetation Science 23: 648–675. https://doi.org/10.1111/avsc.12519

Dengler J, Dembicz I (2023) Should we estimate plant cover in percent or on ordinal scales? Vegetation Classification and Survey 4: 131–138. https://doi.org/10.3897/VCS.98379

Dengler J, Kozub Ł (2022) Nordic-Baltic Grassland Vegetation Database (NBGVD) – News and call for contributions. Palaearctic Grasslands 54–55: 47–48. https://doi.org/10.21570/EDGG.PG.54-55.48-58

Dengler J, Löbel S (2006) The basiphilous dry grasslands of shallow, skeletal soils (*Alysso-Sedetalia*) on the island of Öland (Sweden), in the context of North and Central Europe. Phytocoenologia 36: 343–391. https://doi.org/10.1127/0340-269X/2006/0036-0343

Dengler J, Rūsiņa S (2012) Database Dry Grasslands in the Nordic and Baltic Region. Biodiversity & Ecology 4: 319–320. https://doi.org/10.7809/b-e.00114

Dengler J, Löbel S, Boch S (2006a) Dry grassland communities of shallow, skeletal soils (*Sedo-Scleranthenea*) in northern Europe. Tuexenia 26: 159–190.

Dengler J, Rūsiņa S, Boch S, Bruun HH, Diekmann M, Dierßen K, Dolnik C, Dupré C, Golub VB, … Zobel M (2006b) Working group on dry grasslands in the Nordic and Baltic region – Outline of the project and first results for the class *Festuco-Brometea*. Annali di Botanica, Nuova Serie, 6: 1–28.

Dengler J, Jansen F, Glöckler F, Peet RK, De Cáceres M, Chytrý M, Ewald J, Oldeland J, Lopez-Gonzalez G, … Spencer N (2011) The Global Index of Vegetation-Plot Databases (GIVD): a new resource for vegetation science. Journal of Vegetation Science 22: 582–597. https://doi.org/10.1111/j.1654-1103.2011.01265.x

Dengler J, Becker T, Conradi T, Dolnik C, Heindl-Tenhunen B, Jensen K, Kaufmann J, Klotz M, Kurzböck C, … Went J (2017) GrassVeg.DE – die neue kollaborative Vegetationsdatenbank für alle Offenlandhabitate Deutschlands. Tuexenia 37: 447–455.

Dengler J, Becker T, Heinken T, Kurzböck CM, Pätsch R (2018a) News from GrassVeg.DE, the German grassland vegetation database. Palaearctic Grasslands 38: 26–29. https://doi.org/10.21570/EDGG.PG.37.26-29

Dengler J, Wagner V, Dembicz I, García-Mijangos I, Naqinezhad A, Boch S, Chiarucci A, Conradi T, Filibeck G, … Biurrun I (2018b) GrassPlot – a database of multi-scale plant diversity in Palaearctic grasslands. Phytocoenologia 48: 331–347. https://doi.org/10.1127/phyto/2018/0267

Dengler J, Jansen F, Chusova O, Hüllbusch E, Nobis MP, Van Meerbeek K, Axmanová I, Bruun HH, Chytrý M, … Gillet F (2023) Ecological Indicator Values for Europe (EIVE) 1.0. Vegetation Classification and Survey 4: 7–29. https://doi.org/10.3897/VCS.98324

Dierßen K, Dierßen B (1996) Vegetation Nordeuropas. Ulmer, Stuttgart, DE, 838 pp.

Engel T, Bruelheide H, Hoss D, Sabatini FM, Altmann J, Arfin-Khan MAS, Aubin I, Bergmeier E, Černý T, … Pillar V (2023) Traits of dominant plant species drive normalized difference vegetation index in grasslands globally. Global Ecology and Biogeography 32: 695–706. https://doi.org/10.1111/geb.13644

Euro+Med (2022) Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity. http://www.europlusmed.org [accessed on 21 March 2022]

Hennekens SM, Schaminée JHJ (2001) TURBOVEG, a comprehensive data base management system for vegetation data. Journal of Vegetation Science 12: 589–591. https://doi.org/10.2307/3237010

Hodgetts NG, Söderström L, Blockeel TL, Caspari S, Ignatov MS, Konstantinova NA, Lockhart N, Papp B, Schröck C, … Porley RD (2020) An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus. Journal of Bryology 42: 1–116. https://doi.org/10.1080/03736687.2019.1694329

Jiménez-Alfaro B, Aunina L, Carbognani M, Dítě D, Fernández-Pascual E, Garbolino E, Hájek O, Hájková P, Ivchenko TG, … Hájek M (2023) Habitat-based biodiversity responses to macroclimate and edaphic factors in European fen ecosystems. Global Change Biology 29: 6756–6771. https://doi.org/10.1111/gcb.16965

Jiroušek M, Peterka T, Chytrý M, Jiménez-Alfaro B, Kuznetsov OL, Pérez-Haase A, Aunina L, Biurrun I, Dítě D, … Hájek M (2022) Classification of European bog vegetation of the *Oxycocco-Sphagnetea* class. Applied Vegetation Science 25: e12646. https://doi.org/10.1111/avsc.12646

Knollová I, Chytrý M, Bruelheide H, Dullinger S, Jandt U, Bernhardt-Römermann M, Biurrun I, de Bello F, Glaser M, … Essl F (2024) ReSurveyEurope: a database of resurveyed vegetation plots in Europe. Journal of Vegetation Science (in press).

Kuzemko A (2012) Ukrainian Grasslands Database. Biodiversity & Ecosystems 4: 430–430. https://doi.org/10.7809/b-e.00217

Marcenò C, Guarino R, Loidi J, Herrera M, Isermann M, Knollová I, Tichý L, Tzonev RT, Acosta ATR, … Chytrý M (2018) Classification of European and Mediteranean coastal dune vegetation. Applied Vegetation Science 21: 533–559. https://doi.org/10.1111/avsc.12379

Mucina L, Bültmann H, Dierßen K, Theurillat J-P, Raus T, Čarni A, Šumberová K, Willner W, Dengler J, … Tichý L (2016) Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Applied Vegetation Science 19(Suppl. 1): 3–264. https://doi.org/10.1111/avsc.12257

Pätsch R, Jašková A, Chytrý M, Kucherov IB, Schaminée JHJ, Bergmeier E, Janssen JAM (2019) Making them visible and usable – vegetation-plot observations from Fennoscandia based on historical species-quantity scales. Applied Vegetation Science 22: 465–473. https://doi.org/10.1111/avsc.12452

Peterka T, Hájek M, Jiroušek M, Jiménez-Alfaro B, Aunina L, Bergamini A, Dite D, Felbaba-Klushyna L, Graf U, … Chytrý M (2017) Formalized classification of European fen vegetation at alliance level. Applied Vegetation Science 20: 124–142. https://doi.org/10.1111/avsc.12271

Peterka T, Hájková P, Jiroušek M, Hinterlang D, Chytrý M, Aunina L, Deme J, Lyons M, Seiler H, … Hajek M (2023) Formalised classification of the class *Montio-Cardaminetea* in Europe: towards a consistent system of spring vegetation. Preslia 95: 347–383. https://doi.org/10.23855/preslia.2023.347

Sabatini FM, Lenoir J, Hattab T, Arnst EA, Chytrý M, Dengler J, De Ruffray P, Hennekens SM, Jandt U, … Bruelheide H (2021) sPlotOpen – An environmentally-balanced, open-access, global dataset of vegetation plots. Global Ecology and Biogeography 30: 1740–1764. https://doi.org/10.1111/geb.13346

Sabatini FM, Jiménez-Alfaro B, Jandt U, Chytrý M, Field R, Kessler M, Lenoir J, Schrodt F, Wiser SK, … Bruelheide H (2022) Global patterns of vascular plant alpha diversity. Nature Communications 13: [Article] 4683. https://doi.org/10.1038/s41467-022-32063-z

Schaminée JHJ, Hennekens SM, Chytrý M, Rodwell JS (2009) Vegetation-plot data and databases in Europe: an overview. Preslia 81: 173–185.

Tichý L (2002) JUICE, software for vegetation classification. Journal of Vegetation Science 13: 451–453. https://doi.org/10.1111/j.1654-1103.2002.tb02069.x

Trass H, Malmer N (1973) North European approaches to classification. In: Whittaker RH (Ed.) Ordination and classification of communities, Junk, The Hague, NL, 529–574. https://doi.org/10.1007/978-94-010-2701-4_18

Tutin TG, Heywood VH, Burges NA, Valentine DH, Walters SM, Webb DA [Eds] (1964–1980) Flora Europaea 1–5. Cambridge University Press, Cambridge, UK.

Vassilev K, Dajić Z, Cušterevska R, Bergmeier E, Apostolova I (2012) Balkan Dry Grasslands Database. Biodiversity & Ecology 4: 330–330. https://doi.org/10.7809/b-e.00123

Vassilev K, Ruprecht E, Alexiu V, Becker T, Beldean M, Biță-Nicolae C, Csergő AM, Dzhovanova I, Filipova E, … Dengler J (2018) The Romanian Grassland Database (RGD): historical background, current status and future perspectives. Phytocoenologia 48: 91–100. https://doi.org/10.1127/phyto/2017/0229

Večeřa M, Axmanová I, Padullés Cubino J, Lososová Z, Divíšek J, Knollová I, Aćić S, Biurrun I, Boch S, … Chytrý M (2021) Mapping species richness of plant families in European vegetation. Journal of Vegetation Science 32: e13035. https://doi.org/10.1111/jvs.13035

Večeřa M, Axmanová I, Chytrý M, Divíšek J, Ndiribe C, Čeplová N, Aćić S, Bahn M, Bergamini A, … Lososová Z (2023) Decoupled phylogenetic and functional diversity in European grasslands. Preslia 95: 413–445. https://doi.org/10.23855/preslia.2023.413

Willner W, Kuzemko A, Dengler J, Chytrý M, Bauer N, Becker T, Bita-Nicolae C, Botta-Dukát Z, Čarni A, … Janišová M (2017) A higher-level classification of the Pannonian and western Pontic steppe grasslands (Central and Eastern Europe). Applied Vegetation Science 20: 143–158. https://doi.org/10.1111/avsc.12265

Willner W, Roleček J, Korolyuk A, Dengler J, Chytrý M, Janišová M, Lengyel A, Aćić S, Becker T, … Yamalov S (2019) Formalized classification of the semi-dry grasslands of central and eastern Europe. Preslia 91: 25–49. https://doi.org/10.23855/preslia.2019.025

Wiser SK (2016) Achievements and challenges in the integration, reuse and synthesis of vegetation plot data. Journal of Vegetation Science 27: 868–879. https://doi.org/10.1111/jvs.12419

E-mail and ORCID

Nadiia Skobel (nskobel@ksu.ks.ua), ORCID: https://orcid.org/0000-0003-4354-2881
Łukasz Kozub (lkozub@uw.edu.pl), ORCID: https://orcid.org/0000-0002-6591-8045
Iwona Dembicz (iwona.dembicz@uw.edu.pl), ORCID: https://orcid.org/0000-0002-6162-1519
Steffen Boch (steffen.boch@wsl.ch), ORCID: https://orcid.org/0000-0003-2814-5343
Hans Henrik Bruun (hhbruun@bio.ku.dk), ORCID: https://orcid.org/0000-0003-0674-2577
Olha Chusova (olgachusova28@gmail.com), ORCID: https://orcid.org/0000-0002-8081-9918
Valentin Golub (vbgolub2000@mail.ru), ORCID: https://orcid.org/0000-0003-3973-6608
Aveliina Helm (aveliina.helm@ut.ee), ORCID: https://orcid.org/0000-0003-2338-4564
Dmytro Iakushenko (d.iakushenko@wnb.uz.zgora.pl), ORCID: https://orcid.org/0000-0002-3463-7785
Paweł Pawlikowski (p.pawlikowski@uw.edu.pl), ORCID: https://orcid.org/0000-0002-0656-5067
Piotr Zaniewski (piotr_zaniewski@sggw.edu.pl), ORCID: https://orcid.org/0000-0002-0792-9854
Jürgen Dengler (Corresponding author, juergen.dengler@zhaw.ch), ORCID: https://orcid.org/0000-0003-3221-660X

Supplementary material

Supplementary material 1
Bylaws of the NBGVD (*.pdf)
Link: https://doi.org/10.3897/VCS.119968.suppl1

Supplementary material 2
List of all data sources currently contained in NBGVD (*.pdf)
Link: https://doi.org/10.3897/VCS.119968.suppl2

Supplementary material 3
Additional descriptive statistics of the current content of NBGVD (*.pdf)
Link: https://doi.org/10.3897/VCS.119968.suppl3